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Smoke detector with aspiration unit and flow sensor

Abstract:

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(71) Applicant: **PITTWAY CORPORATION**
Chicago, Illinois 60606 (US)

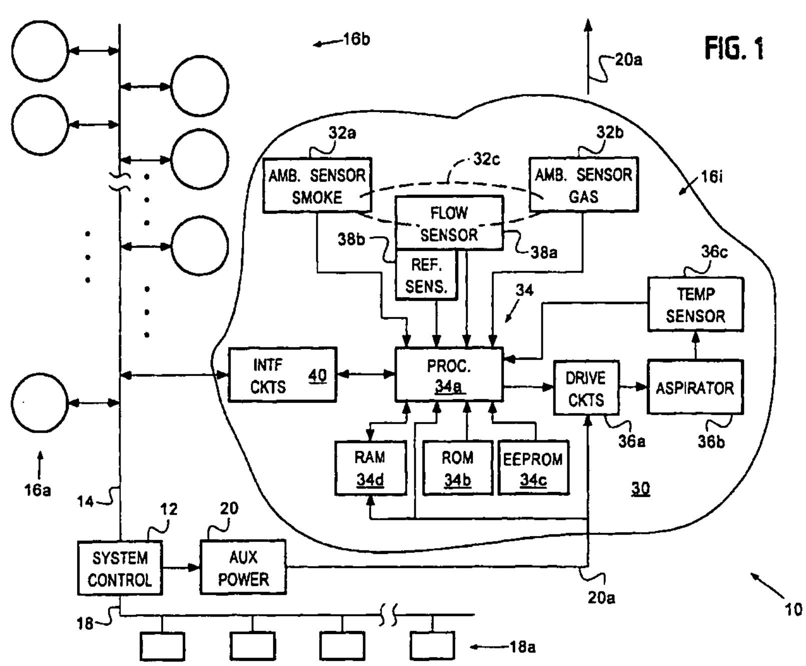
(72) Inventors:
- **Schoenfelder, George A.**
Batavia, Illinois 60510 (US)
- **Shoaff, Thomas**
Warrenville, Illinois 60555 (US)
- **Daly, Juliette C.**
Chicago, Illinois 60601 (US)
- **Gonzales, Eric V.**
Aurora, Illinois 60504 (US)

(74) Representative: **Vigars, Christopher Ian et al**
Haseltine Lake & Co.,
Imperial House,
15-19 Kingsway
London WC2B 6UD (GB)

(54) **Smoke detector with aspiration unit and flow sensor**

(57) A detector includes a smoke sensor and an aspiration unit. The aspiration unit causes ambient air from a region directly adjacent to the detector to flow into a sensing region of the sensor. A flow monitoring sensor provides feedback to a control circuit to vary pulse modulated drive signals coupled to the aspiration unit. A plurality of variable resistance temperature sensors can be used for flow monitoring. Communication with the detector can be carried out via interface circuits.

FIG. 1



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Description

Field of the Invention:

[0001] The invention pertains to ambient condition detectors. More particularly, it pertains to improvements in such detectors.

Background of the Invention:

[0002] Ambient condition detectors have been found to be useful in providing an indication of the presence of the respective condition. Smoke detectors have been found useful in providing early warnings of the presence of airborne particulate matter such as smoke.

[0003] Known smoke detectors often include a housing with an internal sensing region or smoke chamber. Either an ionization-type or a photoelectric-type smoke sensor can be located in the housing.

[0004] Vents are located in the housing. Ambient air circulates into and out of the housing in response to movement of the adjacent atmosphere.

[0005] Air circulation in a region being monitored does bring the airborne particulate matter into the housing. Depending on the nature of the air currents, this can be a faster or a slower process.

[0006] In large commercial buildings, air circulation is often achieved by centralized heating and cooling systems. Building control systems alter air flow in response to preset schedules. Hence, there may be times of minimal or no circulation such as evenings or weekends. There continues to be a need for solutions to these minimal or no circulation situations.

Summary of the Invention:

[0007] An aspirated detector includes at least one ambient condition sensor, such as a smoke or a gas sensor, which is in turn coupled to a control circuit. The control circuit could be implemented, at least in part, as a programmed processor. Read-write memory as well as read-only memory and electrically alterable programmable read-only memory can be coupled to the processor to provide storage for transient information, control programs or calibration information which might be subject to change either between units or as a function of time.

[0008] In one aspect, the detector can include a flow sensor coupled to the control circuitry. The flow sensor could include, for example, at least one thermistor. A second, reference, thermistor can be provided to null out temperature, aging, or ambient effects providing only an indication of flow.

[0009] In one aspect, the aspiration unit can incorporate a fan, centrifugal blower or pump configured to produce either positive or negative pressures so as to draw ambient air from outside of the detector into a sensing volume adjacent to the ambient condition sensor or sensors. Operational temperature of the aspiration unit can be monitored via a temperature sensor. One possible monitorable temperature is the air temperature at the outlet of the aspiration unit. The output of one or more temperature sensors can be fed back to the control circuitry to provide another indication of detector operation.

[0010] The aspiration unit (fan, blower, or pump) could be made small enough to fit within the smoke sensor chamber. If the unit is made small enough that it will not generate an appreciable pressure difference for the purpose of forcing ambient air into the sensing chamber, two approaches can be taken. First, the sensing chamber volume can be decreased until the aspiration unit's output volume becomes substantial enough to cause an inflow of ambient air into the chamber. Secondly, the intensity of the sensor can be increased and/or concentrated such that the sensing region is very small and the outlet of the aspirating mechanism is directly adjacent to the sensing region. For example, in a photoelectric smoke detector, the light producing element can be a focused laser diode rather than an LED. The aspirator outlet fan be directed at the focal point of the laser beam.

[0011] The control circuitry, via drive circuits, can provide pulse modulated drive signals to an aspiration unit. Other types of modulation can also be used.

[0012] In yet another aspect, interface circuitry can be coupled to the control circuitry to enable the detector to communicate, perhaps via a communication link, to a remote system control unit. Data pertaining to sensed ambient conditions as well as status information pertaining to the condition of the detector can be provided, via the interface circuitry, to the system control unit.

[0013] In yet another aspect, electrical energy for the purpose of energizing at least the aspiration unit can be provided via a separate power link from an auxiliary power supply which operates under the control of the system control unit. In yet another embodiment, the power supply for the aspiration unit can be incorporated into the detector.

[0014] In normal operation, as set forth in the parent hereto, the aspiration unit is energized to bring ambient air into the sensing volume or chamber while the ambient condition sensor is active to respond to the presence of the selected condition to be sensed. Hence, the inflow of ambient air, produced by the aspiration unit, provides a higher concentration of the condition to be sensed sooner than would be the case if just the ambient air currents were present.

[0015] A flow parameter or parameters of the ambient air in the sensing volume as well as the temperature of the aspiration unit can be monitored by the local control circuitry. Drive signals provided to the aspiration unit can be modulated in response to the monitored parameters. Parameter monitoring can be simultaneous with ambient condition sensing or interleaved therewith. Signals from the ambient condition sensor can be filtered or processed.

[0016] The detector, in one embodiment, can incorporate at least one, replaceable, filter. The filter can, for example, be implemented as a planar element having one portion to filter inflowing ambient air and a second portion to filter outflowing ambient air from the sensing chamber.

[0017] The filter can be coated in whole or in part with a hydrophobic coating to resist moisture build up and clogging. In yet another aspect, an impervious cover can be provided over the filter to protect it from directly incident streams of water or airborne moisture.

[0018] In yet another aspect,the replaceable filter can be combined with a permanent detector mounted filter. In this embodiment, the pore-size of the replaceable filter is selected to be smaller than or equal to the pore size of the permanent filter. Hence, the replaceable filter can be changed in accordance with a predetermined maintenance schedule as it will tend to clog before the permanent filter does. During the short replacement interval, the permanent filter functions to prevent particulates from entering the sensing chamber of the detector.

[0019] The control circuitry can detect the presence of a filter that has been clogged to a predetermined degree by sensing a loss of flow of ambient air through the sensing chamber, or a temperature increase in the aspiration unit. That circuitry can, via the interface circuitry, communicate with the system control unit and transmit an appropriate status message. In yet another aspect, in response to a clogged filter or a failed aspiration unit, the local control processor can generate a local indicator. The ambient condition sensors could still be monitored by the local control circuitry and indicate via the interface circuitry any detected alarm conditions.

[0020] The local processor can carry out a calibration process in response to an initial power up after assembly. During this process, calibration information that was prestored during manufacture can be read by the processor and incorporated into the detector's control program for use after installation. If desired, the calibration information can then be erased.

[0021] A random delay in energizing a respective aspiration unit can be incorporated into each detector. This will minimize peak power demand needed to drive a plurality of aspiration units.

[0022] The detector can be part of a multi-processor communication system. Wired or wireless communication media can be used to communicate messages between devices.

[0023] In yet another aspect, the ambient condition sensor can be implemented as either a photoelectric or an ionization-type sensor. Photoelectric sensors can incorporate a laser diode as a source of radiant energy. Other sources could be used.

[0024] Numerous other advantages and features of the present invention will become readily apparent from the following detailed description of the invention and the embodiments thereof, from the claims and from the accompanying drawings.

Brief Description of the Drawings:

[0025]

Fig. 1 is a block diagram of an alarm system in accordance with the present invention;

Fig. 2A is a view, partly in section, of an ambient condition detector usable in the alarm system of Fig. 1;

Fig. 2B is an exploded view of the detector of Fig. 2A;

Fig. 3A is a multi-element top plan view of a filter element usable in the detector of Fig. 2A;

Fig. 3B is a side elevational view of the filter of Fig. 3A;

Fig. 3C is a top plan view the assembled elements of the filter of Fig. 3A;

Fig. 4A is an enlarged view, partly in section, of the detector of Fig. 2A illustrating exemplary flow paths;

Fig. 4B is an enlarged view, partly in section, of the detector of Fig. 2A rotated 90° from the view of Fig. 4A;

Fig. 5A is an enlarged view, partly in section, of an alternate form of the detector Fig. 2A illustrating alternate exemplary flow paths;

Fig. 5B is a view in perspective of the filter of Fig. 3C illustrating flow patterns for the detector of Fig. 5A;

Fig. 5C is a top plan view of the detector of Fig. 5A; and

Fig. 6 is a flow diagram illustrating one mode of operating a detector as illustrated in Fig. 1.

Detailed Description of the Preferred Embodiments:

[0026] While this invention is susceptible of embodiment in many different forms, there are shown in the drawings and will be described herein in detail specific embodiments thereof with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the specific embodiments illustrated.

[0027] Fig. 1 illustrates a block diagram of an alarm system 10. The system 10 includes a common system control element 12 which could incorporate a programmed processor. A bidirectional communication medium 14 coupled between control element 12 and a plurality of ambient condition sensors 16a, 16b makes it possible for the control element to carry on bidirectional communications with the members of the respective pluralities. One exemplary medium 14 corresponds to an electric or optical cable. A wireless medium could also be used.

[0028] By way of example and without limitation, the members of the plurality 16a could be ambient condition detectors, such as fire detectors, intrusion detectors or the like. The members of the plurality 16b correspond

to aspirated detectors with flow sensors.

[0029] The system 10 can also include an alarm indicating device bus 18 to which a plurality of audible and visual alarms such as horns, sirens or strobe lights 18a can be coupled. The system 10 can also incorporate an auxiliary power supply 20 coupled to the control element 12.

[0030] The power supply 20 via an auxiliary power bus 20a can provide supplemental electrical energy to the members of the plurality 16b. It will also be understood that instead of a common auxiliary supply such as the supply 20, each of the members of the plurality 16b could be equipped with a local power supply which could be energized via batteries or local utility lines.

[0031] The members of the plurality 16b are substantially identical. A discussion of a representative member thereof, 16i, will also be applicable to the remaining members of the plurality.

[0032] The detector 16i includes a housing 30. The housing 30 carries at least one ambient condition sensor, a smoke sensor 32a. A variety of sensor structures can be used to implement the sensor 32a. The details of the structure of that sensor are not a limitation of the present invention.

[0033] The detector 16i can also incorporate at least one additional optional, ambient condition sensor 32b. The sensor 32b could, for example, sense the presence of one or more selected gases. For example, carbon monoxide is a gas usually associated with a fire condition. Various types of carbon monoxide or gas sensors are known and could be incorporated into the detector 16i. The details of the structure and operation of the sensor 32b are not a limitation of the present invention.

[0034] The outputs from the sensor 32a and/or 32b are coupled to control circuitry 34. The circuitry 34 could be implemented using a programmed processor 34a.

[0035] Programs or instructions for the processor 34a can be stored in read-only memory 34b or electrically erasable read-only memory 34c. Read-write memory 34d, coupled with the processor 34a, is available for temporary storage of data received from various sensors present in the detector.

[0036] The processor 34a is also electrically coupled to drive circuitry 36a. The drive circuitry in turn is coupled to an aspirator 36b.

[0037] The aspirator could be implemented as a pump, fan or blower such as a centrifugal blower. Alternately, the aspirator 36b could be implemented as any other form of air moving device suitable to create either positive or negative pressures so as to cause ambient air to flow into a sensing region 32c associated at least with the smoke sensor 32a and/or the gas sensor 32b.

[0038] An optional temperature sensor 36c can be coupled to the aspirator 36b for the purpose of monitoring the temperature thereof during operation. The temperature sensor 36c is in turn coupled to the processor 34a.

[0039] Flow into the sensing region 32c can be detected by a flow sensor 38a. In one embodiment, the flow sensor 38a can be implemented as a self-heating thermistor. Temperature variations therein due to a flow of ambient air thereacross due to aspirator 36b will be detectable by the processor 34a and can be used to control electrical signals provided to the aspirator 36b by drive circuits 36a. During manufacture, a calibration value can be read off of thermistor 38a and stored in memory 34c for carrying out flow tests in the field.

[0040] In one aspect, and without limitation, the drive circuits 36a can provide modulated pulses, such as pulse width modulated pulses, to intermittently energize the aspirator 36b. This form of operation is desirable not only for purposes of conserving energy but for exercising more precise control over the operation of the aspirator 36b.

[0041] A reference sensor 38b, which could be a second thermistor, can be coupled to the processor 34a to null out any non-flow variations. These variations include, without limitation, temperature variations or aging which might affect the output of the flow sensor 38a.

[0042] In a preferred embodiment, the sensing thermistor 38a is normally not energized. When a test is to be conducted, the aspirator 36b and thermistor 38a are both energized. The output from thermistor 38a can then be sensed at processor 34a and compared to a prestored calibration constant stored in memory 34c. Any substantial deviation from the prestored value is indicative of a change in air flow. After the test process has been concluded, the thermistor 38a can be de-energized. Drive circuits 36a can resume their energy saving intermittent energization of the aspirator 36b.

[0043] Interface circuits 40 coupled to the processor 34a enable the detector 16i to carry out bidirectional communications, via the link 14 with the control element 12. A variety of communications protocols could be implemented on the link 14 without departing from the spirit and scope of the present invention. Where detector 16i communicates wirelessly, circuits 40 could include an RF transceiver.

[0044] The EEPROM 34c can be, if desired, used to store calibrated threshold information for use in analyzing output signals from the flow sensor 38a alone or in combination with reference sensor 38b. It will be understood that the processor 34a can be implemented with any one of a variety of commercially available programmable control processors without departing from the spirit and scope of the present invention. The exact details of the processor 34a, ROM memory 34b, EEPROM memory 34c and read-write memory 34d are not limitations of the present invention.

[0045] Figs. 2A and 2B illustrate different views of a representative member of the plurality 16b, such as the detector 16i. Fig. 2A a side elevational view, partly in section, illustrating various inter-relationships of the elements of the detector 16i. Fig. 2B, an exploded, side elevational view, partly in section, illustrates additional details of the detector 16i.

[0046] As illustrated in Figs. 2A and 2B, the housing 30 surrounds and contains ambient condition sensing elements, such as the smoke sensor 32a or alternately gas sensor 32b. The processor 34a as well as associated storage circuitry 34b, c, d are all carried on and interconnected by a printed circuit board 40.

[0047] The ambient condition sensing elements, such as 32a and 32b, are received within a surrounding skirt 30a. The detector 16i can removably engage a base 30b. The base 30b can be of a type which is intended to be attached to a ceiling or other mounting surface. The link 14 as well as the supplemental power link 20a can be coupled to each of the respective detectors, such as the detector 16i through the mounting bracket or base 30b.

[0048] As illustrated in Figs. 2A and 2B, the housing 30 carries a non-replaceable filter element 42a. The aspirator 36b, which could be a centrifugal blower, draws in adjacent ambient atmosphere through a portion of the filter 42a into the sensing chamber 32c and in turn expels ambient air in the sensing chamber through another portion of the filter portion 42a. A replaceable filter 42b overlays the permanent filter 42a. The replaceable filter 42b is selected so as to have pore sizes that are the same as or smaller than the permanent filter 42a.

[0049] Replacement of the filter 42b on a periodic basis substantially eliminates the possibility of the permanent filter 42a becoming clogged. The filters 42a, b are enclosed and protected by a cover 30c.

[0050] The cover 30c provides input and output ports for ambient air being drawn into and expelled from the sensing chamber 32c.

[0051] Figs. 3A, 3B and 3C illustrate further details of the replaceable filter 42b. As illustrated in Fig. 3A, the filter 42b is formed with a planar generally circular frame 46a. The frame 46a includes a plurality of region-defining elements 46b-1, -2, -3 and -4.

[0052] The frame 46a carries and supports a generally cylindrical filter element 48. The filter element 48 can be formed of a nylon mesh having openings on the order of 25 micrometers. The interwoven threads of the mesh can be treated with a hydrophobic coating. Exemplary types of coatings include silicon or fluorinated carbon coatings. The coating will promote beading or rolling off of water droplets which come in contact with the element 48 thereby minimizing adherence to and ultimately clogging of the pores thereof.

[0053] It will be understood that a variety of materials can be used to form the element 48 depending on environmental considerations. For example, a magnetized metal mesh filter can be used in environments having airborne metallic dust.

[0054] Fig. 3B, a side elevational view of the replaceable filter 42b, illustrates further details of the frame 46a.

[0055] As illustrated in Fig. 3C, preferably the filter 42b defines a single contiguous inlet region 50a and a plurality of spaced-apart exhaust regions 50b. The regions 50a and 50b are demarcated from one another by the elements 46b-1,-2, -3 and -4.

[0056] Fig. 4A, an enlarged side sectional view of the detector 16i, illustrates exemplary air flow therein in response to activation of the centrifugal blower 30b. It will be understood that other configurations of flow are possible without departing from the scope and spirit of the present invention.

[0057] As illustrated in Fig. 4A, the cover 30c protects the filters 42a, b from any high velocity air or water streams directly incident upon the detector 16i. The cover 30c also provides a torturous path for atmosphere both entering and exiting the sensing region 32c of the detector thereby aiding in the filtration process.

[0058] As illustrated in Fig. 4A, the cover 30c, in part defines an inlet region 52a which circumferentially surrounds the housing 30. Ambient air brought into the inlet region 52a travels along the interior of the cover 30c to the central inlet region 50a of the filter 42b.

[0059] The interior of the cover 30c carries partitions, illustrated in Fig. 4A as partition 30c-1; which conform to the filter dividing elements 46b-1, -2, -3 and -4. These partitions form a manifold which segregates inlet air being taken via the circumferential slot 52a from outflowing air.

[0060] The circumferential slot 52a can be divided into inflow and outflow regions, consistent with the partitions, such as the partition 30c-1 in the interior of the cover 30c to provide inflow ports and separate outflow ports for the inflowing and outflowing ambient atmosphere. Fig. 4B illustrates detector 16i in section and rotated 90° relative to the view of Fig. 4A. This view illustrates ambient air outflow from the sensing region 32c from exhaust ports on the circumferential opening 52a.

[0061] The circumferential slot 52a can, alternatively, be configured as a single continuous circumferential port whereat inflowing ambient and outflowing ambient respectively enter and leave the detector simultaneously. In the latter instance, there is a possibility of intermixing of inflowing and outflowing ambient. This intermixing does not have any substantial effect on the performance of the detector.

[0062] The cover 30c also carries drainage openings indicated as 30c-2. The intent of the openings 30c-2 is to provide orifices from which moisture can drain from a respective detector. In normal operation and with a normal orientation, the cover 30c can be expected to be at a lower elevation, or below, the skirt 30a thereby promoting drainage.

[0063] It will be understood that alternate arrangements and configurations can be provided for promoting an inflow and an outflow of ambient air into the sensing chamber 32c without departing from the spirit and scope of the present invention. For example, in one alternate, the circumferential slot 52a can be used as an input port for drawing ambient air into the sensing chamber 32c. Separate outflow paths could be provided at the base of the housing 30 adjacent to the decorative skirt 30a. This arrangement would provide unidirectional flow

through the sensing chamber and then out through the base of the housing. Other configurations are also possible.

[0064] Fig. 5A is an enlarged side sectional view of another configuration of a detector 60 usable with the system 10 of Fig. 1. Detector 60 exhibits an air flow unlike that of the detection 16i of Figs. 4A, 4B.

[0065] The detector 60 includes a cylindrical housing 30-1. The housing 30-1 is closed with a cover 30-1c. An annular inlet channel, or port, 62 surrounds the intersection of the housing 30-1 and the cover 30-1c.

[0066] In response to operation of the aspirator 36b, adjacent ambient air is drawn, via annular channel 62 into a sensing chamber 32-1c. Inflowing air, entering via the annular channel 62, passes through the filter 42b in the region 50a as discussed previously. Outflowing air, also as illustrated in Fig. 5B exits the sensing chamber 32-1c through the regions 50b of the filter 42b, as discussed previously. The outflow or exhaust air passes through perforations, best illustrated in Fig. 5C of the cover 30-1c.

[0067] It will be understood that a variety of different perforations or grills can be provided in the cover 30-1c without departing from the spirit and scope of the present invention. For example and without limitation, sets of generally trapezoidal regions 66a, b, c, are illustrated in Fig. 5C. Outflowing air is indicated with "x". Each of the regions illustrates a different exemplary grill arrangement through which outflowing air passes as it leaves the cover 30-1c.

[0068] In 66d, a plurality of holes is indicated through which outflowing air can pass. It will be understood that other variations are possible without departing from the spirit and scope of the present invention.

[0069] Fig. 6, a flow diagram of operation of exemplary detector 16i includes a plurality of calibration/setup steps 100, a plurality of steps 102 illustrative of normal operation, a plurality of steps 104 illustrative of processing in the presence of malfunctions, nonfunctions or trouble conditions, and a plurality of steps 106 illustrative of air flow monitoring of the aspiration unit 36b.

[0070] With respect to the calibration and setup steps 100, in a step 120, the aspiration unit 36b would be energized. In a step 122, outputs from the reference and sensing thermistors 38a, 38b would be measured and representative parameter values established and stored in programmable memory 34c. In a step 124, a random fan or aspiration unit power up delay is created. That delay value could also be stored in programmable memory 34c. In a step 126, prestored calibration information can be erased. In a step 128, the respective detector, for example the detector 16i, would be installed in a system such as the system 10. In a step 130, the pre-established and prestored random delay interval would be permitted to lapse before energizing the aspiration unit or fan 36b.

[0071] Relative to the normal operational steps 102, in a step 140, a respective fan or aspiration unit 36b would be energized for a predetermined time interval such as five seconds. In a step 142, during this interval, continuity of the fan or aspiration unit circuitry is verified by processor 34a in a step 142. If in a step 144 no open or short circuits are detected, the fan or aspiration unit 36b will be de-energized for 30 seconds in a step 146.

[0072] In a step 148, the duration of time since air flow has been monitored is compared to a predetermined interval such as four hours. If the time has not exceeded the preset interval, the aspiration unit or fan is again energized in the step 140.

[0073] Where in the step 144 an open or short circuit has been detected, in a step 152 the number of such detects is compared to a preset value, such as three consecutive times. If the open or short circuit has not been detected in the step 152 for the requisite number of times, the aspiration unit or fan is again de-energized in the step 146. If however the open or short circuit condition has been detected for the requisite number of times, in a step 154, a predetermined trouble signal, discussed subsequently, can be generated for use by common control unit. Subsequent to generating the trouble signal, in a step 156, a predetermined interval is permitted to elapse before retesting continuity and verifying the operation of air flow circuitry in a step 158. where the trouble source has been clear in a step 160, a determination is made in a step 162 as to whether the trouble has been cleared for three successive elapsed time intervals. If not, in a step 164 after a preset delay interval, the fan continuity and air flow circuitry is again rechecked in the step 158. Where the source of trouble has not been cleared in the step 160, after a further delay in the step 156, fan continuity and air flow circuitry are retested again in the step 158.

[0074] Where the trouble source has been detected to have been cleared a predetermined number of times in the step 162, normal operation is resumed in the step 140.

[0075] Where an appropriate time interval has elapsed in the step 148, the air flow monitoring steps 106 will be executed. In a step 170, aspiration unit 36b, which could be implemented as a fan, and air flow sensing circuitry 38a, b are energized for a predetermined time interval, such as 15 seconds. At the end of that time interval, in the step 172, outputs from the flow sensing element 38a and reference element 38b are read. If those values do not fall within a predetermined range, stored for example in programmable memory 34c, the detector will return to normal operation, steps 102, for a predetermined time interval such as one hour.

[0076] If the values do fall within the prestored ranges, step 104, in a step 178 a correlation is established between reference sensing elements 38b and the ambient temperature, which could be detected off of a selected temperature sensor carried by the respective detector. In a step 180, a flow trouble threshold is established based on the sensed ambient temperature. If in a step 182, the output from the sensing element 38a has fallen

below the threshold established in the step 180, the number of times this condition has been detected is compared in a step 184 to a predetermined value such as three times. If so, a trouble signal is generated in the step 154. If not, the aspiration unit 36b is de-energized for a preset time interval in a step 186. Subsequently, the unit is re-energized in this step 170.

[0077] The control circuitry 34a must allow for a fail-safe response to a number of occurrences in the field, such as a clogged filter, a broken fan, an open or short circuit, etc. In the process of Fig. 6, all of these field occurrences are communicated by a trouble signal to the control 12 for the respective aspirated detector. There are a variety of ways to produce a trouble signal, none of which is a limitation of the present invention.

[0078] One method is to produce a trouble signal at the control 12 by cutting the power loop between the detector and the panel using a switch at the detector. This method can be implemented by cutting power permanently, or cutting and restoring power intermittently to maintain smoke sensing ability and to discriminate between types of field occurrences.

[0079] There are a variety of trouble signal intervals that can be implemented, which may be based on the frequency of monitoring by control 12. For example, the intervals can be spaced to produce signals during various work shifts (i.e., every 3-7 hours), across several days (i.e., every 17-23 hours), or regularly (i.e., every 0.5-1 hours).

[0080] A trouble signal at the control 12 can also be generated by altering one of the detector's output signals so that power is maintained continuously, but the control 12 reads a deviation from normal output signals. This can also be achieved using a remote device connected within the medium 14 between the detector and the panel.

[0081] Since the aspiration module 36b may run off of an auxiliary power supply 20, separate from the control 12 power supply to the detector, the detector power source from the control 12 to the auxiliary power supply 20 can be switched in the event of a trouble condition. This way, the medium 14 to the control 12 is disconnected so the control 12 generates a trouble signal, but the detector is still powered (by the auxiliary power supply) so as not to lose smoke sensing ability. In the event of a fire during this condition, the medium 14 can be restored so the fire condition can be communicated through the control 12.

[0082] Another trouble signal method is to use an auxiliary alarm such as an annunciator or a visual display, either attached to the detector or the control 12, or remote from both. Thus, the trouble switch can be connected between the detector and the auxiliary alarm rather than the control 12. Again, the alarm could sound in different patterns or indicate different visual signals to discriminate between field occurrences. Furthermore, a visual display could show the air flow readings and indicate how close the readings are to the trouble threshold; perhaps the characters could turn colors to indicate pre-alarm states.

[0083] From the foregoing, it will be observed that numerous variations and modifications may be effected without departing from the spirit and scope of the invention. It is to be understood that no limitation with respect to the specific apparatus illustrated herein is intended or should be inferred. It is, of course, intended to cover by the appended claims all such modifications as fall within the scope of the claims.

Claims

1. A detector comprising:

   at least one ambient condition sensor;
   a control circuit coupled to the sensor;
   an aspiration unit coupled to the control circuit wherein that unit produces a flow of ambient atmosphere in the vicinity of the sensor; and
   a flow monitoring device, coupled to the control circuit, wherein the device monitors the flow and wherein the control circuit includes circuitry for generating a signal indicative of non-performance of the aspiration unit and wherein the control circuit includes circuitry for storage of selected parameter values.

2. A detector as in claim 1 wherein the unit comprises a centrifugal blower.

3. A detector as in claim 2 wherein the blower produces a positive pressure in the vicinity of the sensor.

4. A detector as in claim 1 wherein the device includes a temperature sensitive circuit element.

5. A detector as in claim 1 wherein the control unit includes circuitry for storing and for reading prestored calibration information.

6. A detector as in claim 4 wherein in response to a reduction in an expected flow, an output parameter of the element moves from a first value to at least a second value.

7. A detector as in claim 6 wherein the device includes a second temperature sensitive element.

8. A detector as in claim 1 which includes a housing which defines at least an inflow port and carries at least one air flow filter.

9. A detector as in claim 8 wherein the filter is planar.

10. A detector as in claim 8 wherein the filter has a first, intake region and a second, outflow region.

11. A detector as in claim 10 wherein the filter is removable.

12. A detector as in claim 8 wherein the housing defines an internal flow path between the port and the filter.

13. A detector as in claim 5 wherein the sensor is selected from a class which includes an ionization-type sensor, a photoelectric sensor and a gas sensor.

14. A detector as in claim 10 wherein at least one of the regions includes at least two separate portions.

15. A detector as in claim 1 wherein the control circuit includes a programmable processor.

16. A detector as in claim 15 wherein the control circuit includes further circuitry for establishing a modulated pulse train for energizing the aspiration unit in response to an output signal from the flow monitoring device.

17. A detector as in claim 8 wherein the sensor, the aspiration unit and the filter are arranged in a stacked configuration relative to a mounting region of the housing with one of the sensor, the unit and the filter being further from the base then another.

18. A detector as in claim 8 wherein the filter carries a hydrophobic coating.

19. A detector as in claim 1 which includes aspiration unit drive circuitry and associated random delay circuitry.

20. A detector as in claim 1 wherein the control circuit includes instructions for carrying out a monitoring function and for generating status signals indicative thereof.

21. A detector as in claim 20 wherein the control circuit incudes instructions for monitoring the status signals and instructions which in response to a malfunction indicating signal, enter into a retest mode.

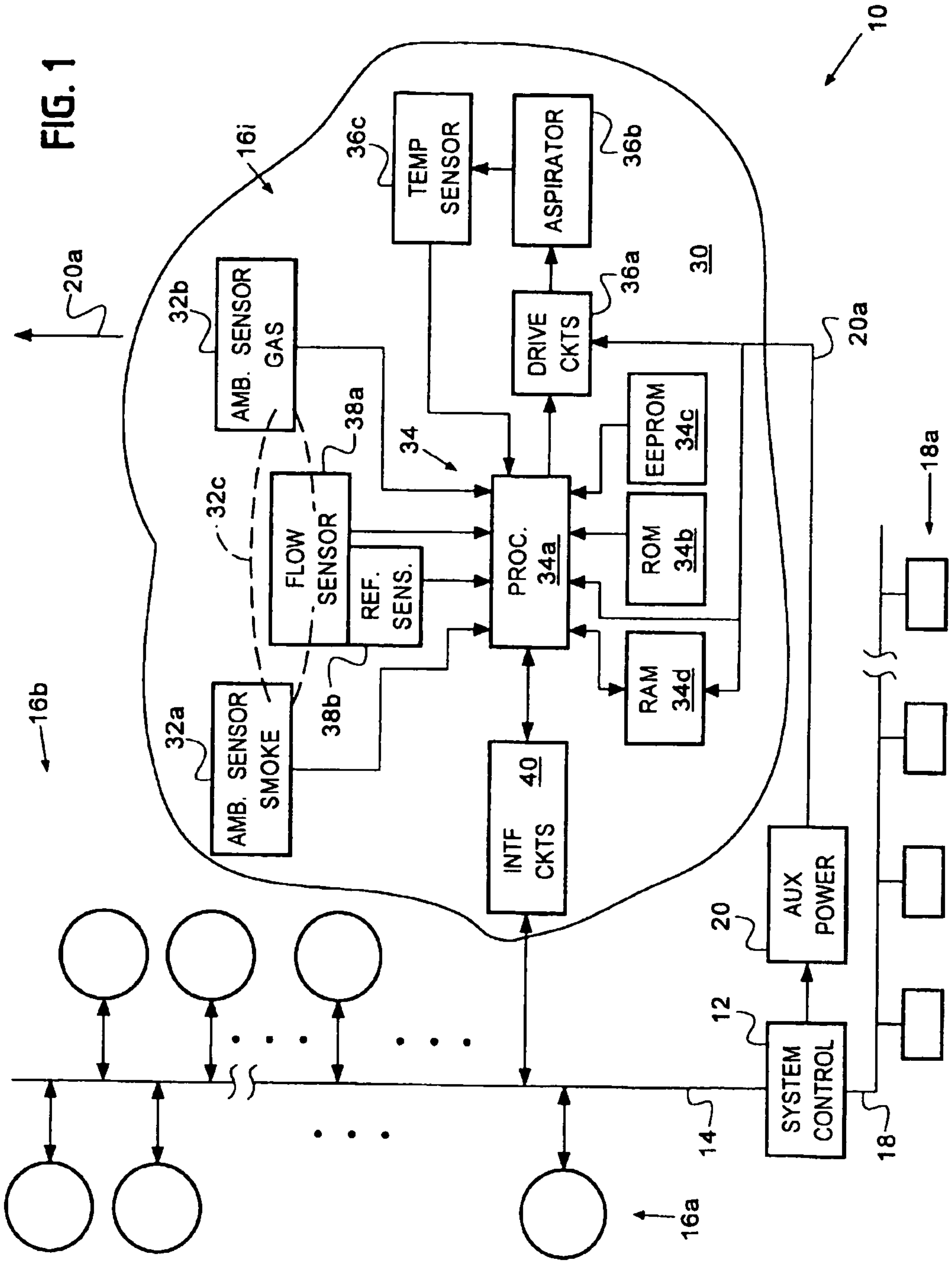

10
16i
16b
16a
20a
AMB. SENSOR GAS
32b
AMB. SENSOR SMOKE
32a
32c
FLOW SENSOR
38a
REF. SENS.
38b
34
PROC. 34a
EEPROM 34c
ROM 34b
RAM 34d
TEMP SENSOR
36c
ASPIRATOR
36b
DRIVE CKTS
36a
30
INTF CKTS 40
AUX POWER
20
SYSTEM CONTROL
12
14
18
18a

FIG. 1

FIG. 2A

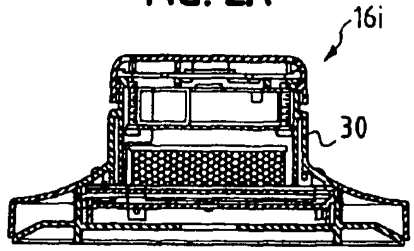
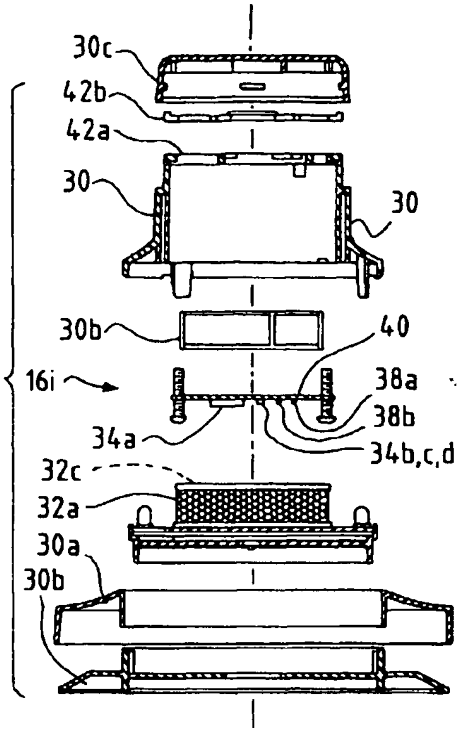


FIG. 2B



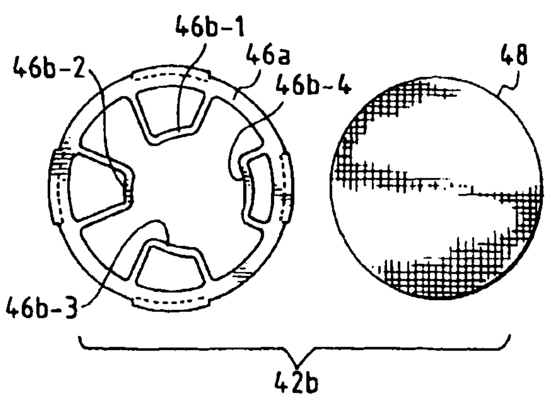


FIG. 3A

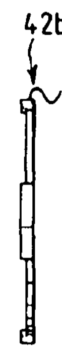


FIG. 3B

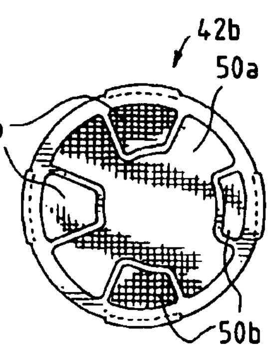


FIG. 3C

FIG. 4A

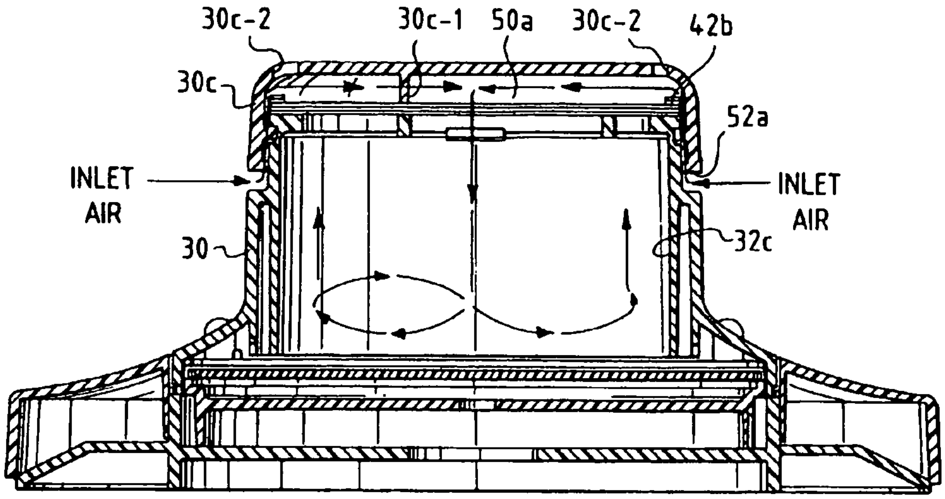

30c-2
30c-1
50a
30c-2
42b
30c
52a
INLET AIR
INLET AIR
30
32c

FIG. 4B

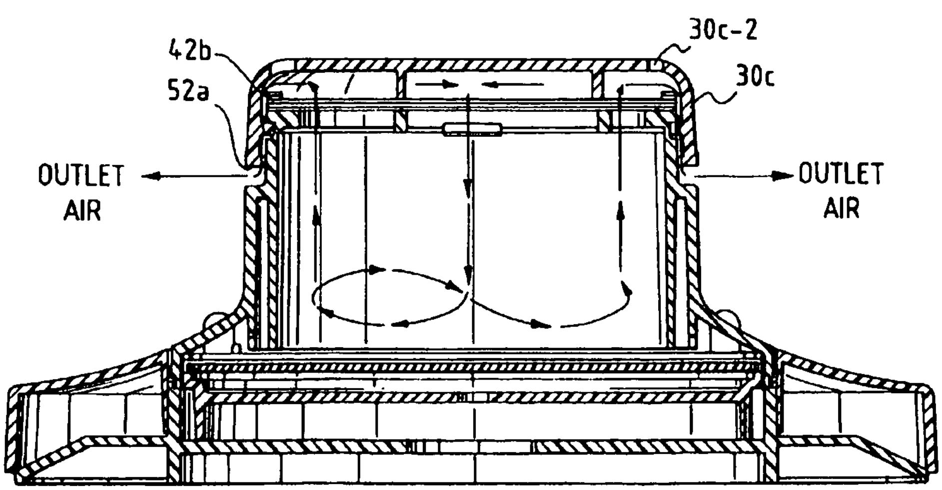

30c-2
42b
30c
52a
OUTLET AIR
OUTLET AIR

FIG. 5A

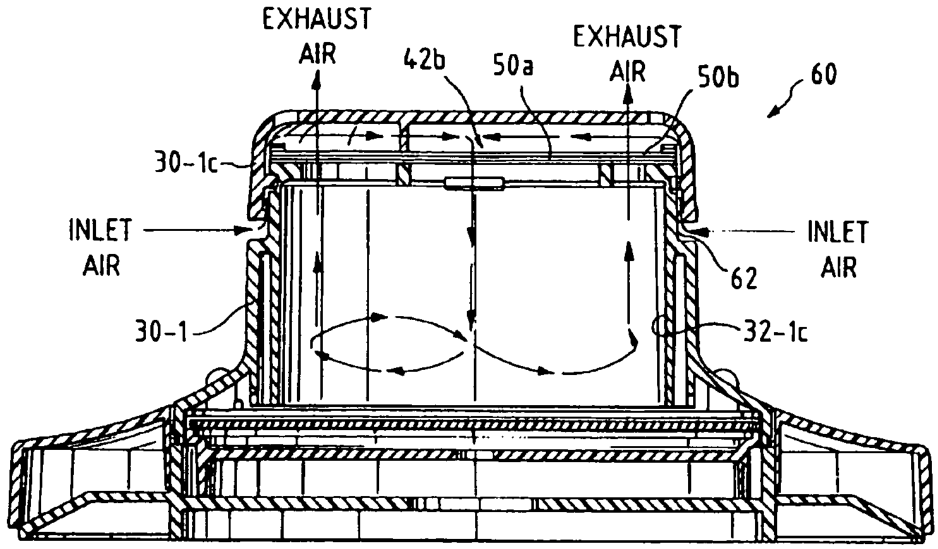

EXHAUST
AIR
42b
50a
EXHAUST
AIR
50b
60
30-1c
INLET
AIR
INLET
AIR
62
30-1
32-1c

FIG. 5B

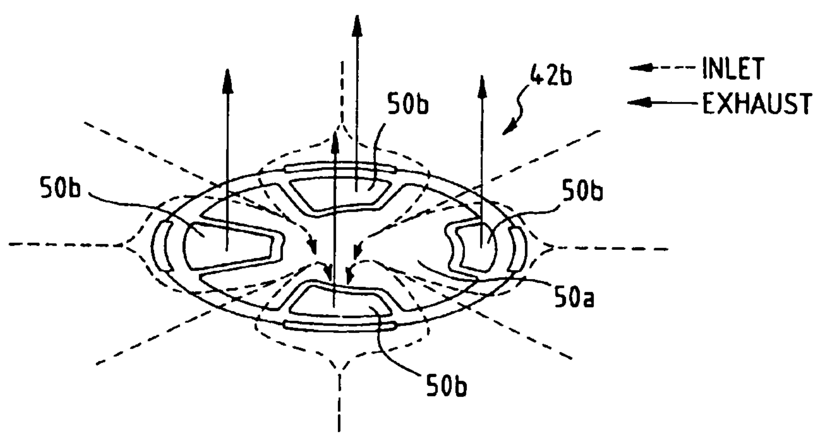
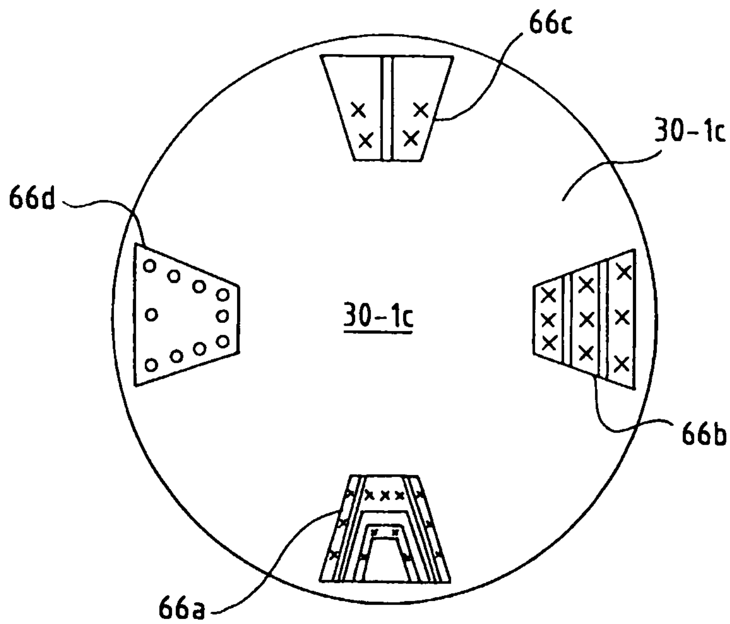

42b
INLET
EXHAUST
50b
50b
50b
50a
50b

FIG. 5C



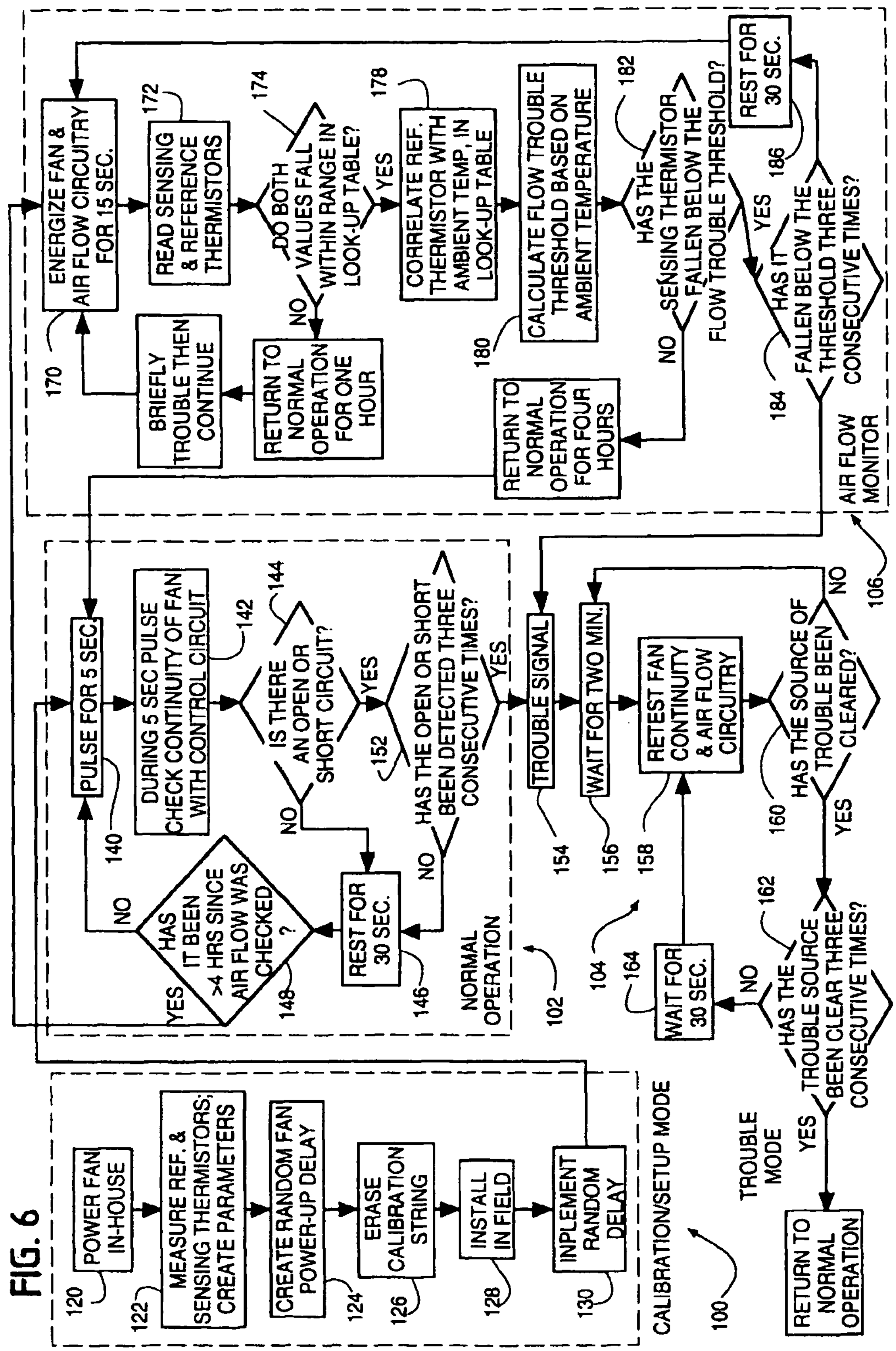

POWER FAN IN-HOUSE
MEASURE REF. & SENSING THERMISTORS; CREATE PARAMETERS
CREATE RANDOM FAN POWER-UP DELAY
ERASE CALIBRATION STRING
INSTALL IN FIELD
INPLEMENT RANDOM DELAY
CALIBRATION/SETUP MODE
120
122
124
126
128
130
100
PULSE FOR 5 SEC.
DURING 5 SEC PULSE CHECK CONTINUITY OF FAN WITH CONTROL CIRCUIT
IS THERE AN OPEN OR SHORT CIRCUIT?
YES
NO
HAS THE OPEN OR SHORT BEEN DETECTED THREE CONSECUTIVE TIMES?
YES
NO
REST FOR 30 SEC.
HAS IT BEEN >4 HRS SINCE AIR FLOW WAS CHECKED ?
NO
YES
NORMAL OPERATION
140
142
144
146
148
152
102
ENERGIZE FAN & AIR FLOW CIRCUITRY FOR 15 SEC.
READ SENSING & REFERENCE THERMISTORS
DO BOTH VALUES FALL WITHIN RANGE IN LOOK-UP TABLE?
YES
NO
RETURN TO NORMAL OPERATION FOR ONE HOUR
BRIEFLY TROUBLE THEN CONTINUE
CORRELATE REF. THERMISTOR WITH AMBIENT TEMP, IN LOOK-UP TABLE
CALCULATE FLOW TROUBLE THRESHOLD BASED ON AMBIENT TEMPERATURE
HAS THE SENSING THERMISTOR FALLEN BELOW THE FLOW TROUBLE THRESHOLD?
YES
NO
RETURN TO NORMAL OPERATION FOR FOUR HOURS
HAS IT FALLEN BELOW THE THRESHOLD THREE CONSECUTIVE TIMES?
REST FOR 30 SEC.
AIR FLOW MONITOR
170
172
174
178
180
182
184
186
106
TROUBLE SIGNAL
WAIT FOR TWO MIN.
RETEST FAN CONTINUITY & AIR FLOW CIRCUITRY
HAS THE SOURCE OF TROUBLE BEEN CLEARED?
NO
YES
HAS THE TROUBLE SOURCE BEEN CLEAR THREE CONSECUTIVE TIMES?
NO
YES
WAIT FOR 30 SEC.
RETURN TO NORMAL OPERATION
TROUBLE MODE
154
156
158
160
162
164
104

FIG. 6